THE ROLE OF BLOOD HEMOGLOBIN CONTENT IN ASTHENOPIA AMONG COMPUTER WORKERS IN JAKARTA, 1998
A Logistic Function Analysis

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ABSTRAK

PERAN MUATAN HEMOGLOBIN DARAH PADA PENDERITA ASTHENOPIA DI ANTARA PARA PEKERJA PENGGUNA KOMPUTER DI JAKARTA TAHUN 1998
Sebuah Analisis Fungsi Logistik

Penggunaan komputer sudah sangat populer di Indonesia dan asthenopia dilaporkan merupakan gangguan utama mata dan penglihatan bagi tenaga kerja pengguna komputer. Sebuah penelitian telah dilakukan pada sebuah perusahaan telekomunikasi Badan Usaha Milik Negara (BUMN) pada pekerja operator menggunakan komputer 'Cathode Ray Tube' (CRT). Tujuan penelitian adalah untuk mengidentifikasi peranan dari hemoglobin darah (Hb) terhadap terjadinya asthenopia. Asthenopia telah diukur secara objektif dengan tes 'photo stress' dan parameter objektifnya adalah waktu pemulihan makula.

Disain penelitian ini berupa studi cross sectional *dengan analisis perbandingan kelompok internal. Populasi penelitian adalah tenaga kerja yang menggunakan komputer dengan keluhan asthenopia berdasarkan anamnesis. Dua kelompok sampel, masing-masing terdiri dari 42 subjek, yaitu kelompok terpajan tinggi merupakan kelompok operator dan kelompok terpajan rendah yang merupakan tenaga kerja administrasi. Variabel dependen adalah waktu pemulihan makula sedangkan variabel-variabel independen usia, jenis kelamin, jenis pemajanan/jenis pekerjaan, Hb, lama bekerja, jarak kerja mata dan monitor komputer serta iluminasi.*

Analisis penelitian telah dilakukan dengan menggunakan analisis logistik fungsi regresi, merupakan sebuah analisis statistik berdasarkan pengembangan model dari variabel. Temuan penelitian menunjukkan bahwa Hb bukan merupakan fator risiko yang signifikan untuk asthenopia. Terbukti bahwa Hb hanya merupakan faktor perancu bagi jenis kelamin terhadap asthenopia pada kelompok operator. Tidak satu pun dari semua variabel independen dibuktikan sebagai faktor risiko bagi asthenopia.Dalam usaha untuk memantau dan mempertahankan produktivitas para tenaga kerja komputer terutama operator, disarankan kepada perusahaan agar melakukan pemeriksaan Hb secara teratur pada para operator.

Kata kunci : Asthenopia, waktu pemulihan makula, Hb darah, faktor risiko, faktor perancu, analisis logistik fungsi regresi.

INTRODUCTION

Computers heve been widely used in Indonesia among workers. Beside the benefits of computers, some negative impacts on health of the workers were observed. World Health Organization reported among complaints and disorders

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related to computer use, eye strain or asthenopia has been the most prevalent, about 40-92% among workers[1]. Asthenopia a subjective complaint makes it very difficult to as measure unless an objective parameter is determined[2]. The high prevalent asthenopia among computer workers will affect their productivity through high absentees, improper work quality and not optimal work during working hours[2].

Anemia or nutritional anemia is also highly prevalent among workers, about 30-50% in Indonesia[3]. Several factors were accounted to anemia such as socioeconomic and cultural factors, as well as food and eating pattern. Husaini, in his study reported that nutritional anemia reduced work productivity between 10-40%[4].

This study tried to identify the relationship between anemia and asthenopia among computer workers in one of the 'BUMN' (*Badan Usaha Milik Negara*) a semi government company, in Jakarta. Study results will be used for the improvement of computer workers quality.

Several factors were accounted as risk factors of asthenopia, i.e., working environment, working distance, work attitude, as well as socio demographic factors age, gender, socio economic, duration of work, types of work, psychologic factors of worker and characteristics of computers and accessories[1,5,6,7,8,9,10]. Some writers divided the risk factors into the intrinsic and extrinsic factors[10]. The intrinsic factors comprised the ocular and body constitution, while illumination and types of objects were considered as the extrinsic factors. Body constitution was determined by physical factors and the general health status was usually measured by blood hemoglobin (Hb) content level.

Working with computer monitor equipped with Cathode Ray Tube (CRT) was basically being exposed to two kinds of exposures, the monitor screen illumination and secondly, working at a short distance between eyes and monitor about 50-60 cms, that could cause transient myopia. Persons with transient myopia will eventually suffer from the sensitivity contrast disruption[9,11]. The photo stress test is a kinetic test performed by using a penlight of 2340 lumen/square meter to evaluate the adjustment of retinal function after being exposed to a drastic change[12,13,14]. The test reflects the exposure, of the computer monitor illumination to one's eyes.

The only difference was in the light intensity in which the computer monitor intensity ranges between 182.70-1015 lumen/square meter[14]. The second exposure was the disturbance of visual acuity and sensitivity contrast measured by Pelli-Robson test[15]. The modification of photostress test combined with Pelli-Robson combined produced the outcome parameter, the macular recovery time (MRT). MRT was considered the objective parameter of measuring asthenopia[2].

MATERIALS AND METHOD

The design of this study was a cross sectional survey among the CRT computer workers in the company. The company has one special department dealing with computer operators, working with computers 24 hours in shift. The workers have a break after working two hours continously. Each shift works 8 hours a day, the morning shift works from 8 a.m till 4 p.m. The operators were the highly exposed as the study group and the low exposed as the control group consisted of administrative workers working with computers daily about 4 hours a day. The criteria of inclusion of subject was suffering from asthenopia during the last four weeks, normal visual acuity, no eye disorders and willing to participate in the study by signing the informed consent. The subjective symptoms of asthenopia were dizzy, eye and vision discomfort, vomiting, diarrhea, sore throat, coughing, headache, unwell feeling, soreneck, lowback pain (waist area) etc.

The calculated sample size (alpha 5%, beta 20%) for each group was n=40, thus the total enrollment was 80[16)]. The samples were taken only from the operator department and the administrative department. Only the morning shift personnels from the operator department were allowed to participate in the study. The other departments were not allowed by the company to participate in the survey due to their hectic schedules of work.

The environmental survey was carried out in the working place environment by measuring illumination, work design or working distance, the ergonomic factors of worker and the computer. All rooms were air conditioned centrally.

Data collection was carried out through interviews and questionnaires, physical examination, laboratory test for hemoglobin and modified photostress test with Pelli-Robson chart. The modified photostress test and Pelli-Robson test were applied to both groups, the study and the control groups before and after one and two hours of working. The procedure was as follows:[2)]

1. First, both subject's eyes were tested for visual acuity with Snellen Optotype chart from the distance of 6 meters, with or without correction.
2. The tes was performed after eyes sensitivity contrast using Pelli-Robson chart from 1 meter distance of subject. The level of sensitivity contrast of subject was determined by subject mentioning correctly two from the three letters from the palest triplet at the Pelli-Robson chart. The tests were binocularly applied.
3. After the two tests, subject was asked to stand at 1 meter distance from the Pelli-Robson chart. Both eyes, then were illuminated with the penlight at the distance of 2-3 cms within 10 seconds. Soon after the penlight is off, subject was asked to reread the triplets he/she read before at the Pelli-Robson chart. Both tests were applied binocularly and the range of illumination from the chart between 60-120cd/square meter.
4. The macular recovery time was measured. The MRT is the amount of time spent by the subject since the penlight is off until the subject could read the two the three palest triplets which of had been rightly read before. MRT was measured in seconds.

Design of analisis

Data analisis were descriptively and analytically carried out using test of association/Odd Ratio (OR), and logistic regression function analysis[17,18)].

Logistic regression function analysis (log-reg) : aimed at identifying the role of Hb more specifically. Logistic regression function is a statistical model building technique. The model represents the comprehensive relationships among assumed risk factors and outcome of interest in a sample or population. For smaller groups another particular models should be developed to obtain more specific results[18]. Two phases were applied in log-reg analysis. The first phase was to identify the potential risk factors through the univariate analysis. The second phase or the Stepwise method was to classify the specific functions of all the potential risk factors in the model as significant risk factors, confounders or effect modifiers.

There were seven models developed, i.e. the total model (A1) with total sample n=84, include all independent variables. Two models stratified by type of exposure, the highly exposed/the operators (A2) and the low exposed/the administrative workers models (A3), with each model n=42. Only four models as results of stratification by type of exposure and gender (n=21) were used. There were eight variables analyzed, the macular recovery time (MRT) as the dependent variable, while the independent variables were type of exposure (ET), age (AGE), gender (SEX), hemoglobin content (Hb), duration of work (WH), illumination (ILL) and working distance (VD). From each model, risk factors with probability (p) less than 20% and biologically meaningful were chosen from the univariate logistic function analysis of risk factors to build the identified model. The identified model will then identify the significant risk factors, confounders and effect modifiers. The confounder is ascertained by comparing the estimated coefficient for the risk factor variable from models containing and not containing the covariate. The covariate is an effect modifier when the interaction term added in the model is both biologically meaningful and statistically significant. The Log-likelihood (LLH) and the Likelihood Ratio Test Statistic (G) determine the significancy of models as well as the identifications of confounders and effect modifiers. If a confounder or an effect modifier was identified to a risk factor then the interaction effect should be eliminated[18].

The operational variables

The dependent variable was the macular recovery time and the independent variables were : age, gender, type of exposure, blood hemoglobin content, duration of work, working distance, and illumination. The working environmental factors were respresented by illumination since the other factors such as temperature, and air density were centrally controlled. Hemoglobin was taken to represent general health status since the results of physical examinations reported all subjects were in good health. Age and gender were taken from the socio demographic factors since education and income of the two groups were significantly different.

- the macular recovery time (MRT)

The MRT was obtained through the combined photostress test and the Pelli-Robson test. It may demonstrate the objective condition of the biochemistry circuit of the visual process within the photoreceptors. The MRT values were taken three times, prior to, after one and two hours of working. The MRT parameter used for analysis was the delta MRT or the deviation of MRT2-MRT1 divided by MRT0 in percent. The cut off point used was 19.78%. More than 19.78% was considered most probable of having asthenopia.

- hemoglobin (Hb)

Hemoglobin content was measured using spectrophotometer Coulter T 540, cyanhemoglobin method and reported in gr%. Normal Hb value for men is ≥14gr%, whereas for women is ≥12gr%[19].

- duration of work (WH)

Duration of work is the proxy duration of exposure to the subject. One year was taken as the borderline assuming that less than one year computer exposures should not affected one's eye yet.

- working distance (VD)

Working distance is the distance (in mm) between the eye and the computer's monitor. The advisable distance is ranging from 450-200 mm[20]. However, this ergonomic condition is affected by the ergonomic factors of chair and computer's desk. The advocated height were 700 mm and 650-750 mm respectively for fixed and adjustable desk, whereby, the height of chair should be 432 mm[21].

- working illumination (ILL)

Working illumination may act as the main extrinsic factor. It has three aspects measured, i.e., the quantity, the quality and the distribution[8]. The illumination was measured in each computer's desk with a lux meter. Two hundred lux was used as the cut off level of proper and improper illumination in this study, although several studies reported 300 lux as the borderline of good illumination. The 200 lux was found as the mean of the illumination values measured.

RESULTS

The descriptive results of study reported several major complaints after working with computers. Among operators were eye and vision discomfort (69.5%), headache (57.8%) and waist pain (37.2%) while neck and shoulder pain (47.7%), headache (29%) and waist pain (21%) were mentioned by administrative workers. Asking the reasons of eye and vision discomfort most of them mentioned the factors of computers 'glare', hectic work, inadequate illumination and uncomfortable seat. Watery eyes and blurred vision were among the major complaints of eye and vision discomfort.

Using the MRT as the objective measure, it was found that among operators there were 21 subjects (50.0%) with MRT > 19.78%, high risk of asthenopia, 21 subjects (50.0%) with MRT < 19.78% while among administrative workers there were only 11 subjects (26.2%), MRT > 19.78% and 31 subjects (73.8%) with MRT < 19.78%.

The statistical analysis results:

There were no significant differences found between the operator and administrative workers groups (p>.05) between variables: age, sex, education, income, hemoglobin, and duration of work. Also regarding the working environment factors: illumination, working distance, there was no significant difference identified between the groups.

The analysis of risk factors for asthenopia.

Table 1 showed several factors considered as risk factors of asthenopia which were individually analyzed for any relationship with asthenopia.

Table 1. The relationships and ORs of type of work/exposure, gender, duration of work, age and Hb towards asthenopia (MRT), after working two hours continuously.

Risk factors	MRT ≤ 19.78%		MRT > 19.78%		OR	CI min max
	Operat.	Contr.	Operat.	Contr.		
1. Type of exposure (operat. & contr.)	21	31	21	11	3.8	1.1-7.0*
2. Gender						
- female	8	17	13	4	6.9	1.8-26.3*
- male	13	14	8	7	1.2	0.4-4.4
3. Dur. of work						
- < 5 years	12	23	9	10	1.7	0.6-5.4
- ≤ 5 years	9	7	12	2	5.9	0.8-42.2
4. Age (in years)						
- 20-29	12	15	9	6	1.9	0.5-6.7
- 30-39	6	7	9	2	6.7	0.8-53.2
5. Hb content						
- good**	20	24	16	11	1.8	0.7-4.6
- bad	1	6	5	1	99.0	2.7-3687.9*

* significant relationship ($p < 0.05$)

** good Hb content : female : ≥ 12 gr%
male : ≥ 14 gr%

Type of work/exposure, women and bad Hb content showed significant differences between the operators and the administrative workers. Operators have the chance 3.8 times to have asthenopia compared to administrative workers. Also women operators tend to have asthenopia 6.9 times compared administrative women workers. With good Hb content meaning for women workers Hb ≥ 12gr% and men workers ≥ 14gr%. With Fisher test p=0.02 (p<0.05), it was proved that there was a significant difference for low/suboptimal Hb between the operators and administrative workers. OR was reported 99.0 with confidence interval (CI) min=2.7 max=3687.9, meaning operators with low/suboptimal Hb have the 3688 times chance to have asthenopia compared with administrative workers with low/ suboptimal Hb.

Table 2 showed the relationship between asthenopia and the working environment factors.

Table 2. The relationships and ORs between work design/working distance, illumination and temperature to asthenopia (MRT).

Risk factors	MRT ≤ 19.78%		MRT > 19.78%		OR	CI
	Operat.	Contr.	Operat.	Contr.		
1. Illumination						
- good	9	22	10	8	3.1	0.9-10.1
- bad	12	8	11	4	1.8	0.4-7.8
2. Working distance						
- good	18	30	15	11	2.3	0.9-6.0
- bad	3	0	6	1	2.2	0.2-20.7

There was no significant difference reported among the relationships of the working environment factors and MRT between the operator and the administrative workers.

Logistic regression function analisis results.

Table 3 reveals the first phase results.

Table 3. Distribution of probabilities (ps) of independent variables coefficients indentified through univariate log-reg analysis in models.

Variables	model A1	model A2	model A3
1. Type of exposure	.03*	-	-
2. Blood Hb content	.52	.11*	.44
3. Age	.97	.34	.27
4. Sex	.65	.13*	.30
5. Duration of work	.05*	.28	.71
6. Illumination	.08*	.92	.46
7. Working distance	.37	.31	.64

p = probability; * = p < 20%

The results of second phase analysis is reported as follows : the subsequent analysis of model A1 (data not shown), distinguished the specific function of potential risk factors of ET, WH and ILL to MRT. ET was considered as the major risk factor while WH and ILL were potential confounders and/or effect modifiers of ET to MRT. The changes of coefficients of ET by the insertions of WH and ILL in the models proved that both variables were confounders for ET. Further more by the insertions of interaction factors between ET-WH and ET-ILL, meaning neither WH nor ILL were proven to be the effect modifier of ET to MRT.

Table 4 shows the results of second phase analyses in model A2.

Table 4. Logistic Regression Coefficients, LLH, Statistic G of Sex and Hb to MRT.

Model	C	Sex	Hb	Sex-Hb	LLH	G
model 1	- .49	.97			55.82	
model 2	- .56	.75	1.58		53.59	4.46*
model 3	- .62	.87	7.82	- 6.68	52.83	1.52

Sex-Hb = the interaction variable between Sex and Hb
LLH = Log-Likelihood
Statistic G = Likelihood Ratio Tes Statistic
* - significant.

There were two covariates which ps < 20%, i.e., the Sex and Hb in model 2. The insertion of Hb showed a significant change of coefficient of Sex (LLH of model 2, 4.46). Thus, it was confirmed that Hb was a confounder for Sex. However, since that the LLH of model 3 was not significant, Hb was not validated as an effect modifier of Sex to MRT. Model 2 also showed that none of the covariates were significant risk factors by looking at the probability of coefficients of Hb (p = .18) and Sex (p = .28)

Since models A4 and A5 were derived from model A2 stratified by Sex, further analysis in both models were to describe the function of Hb. The univariate log function showed that the probabilities of coefficients of Hb in model A5 (p=.83) and model A6 (p=.11) were not significant. Hb was not proven as a significant risk factor for MRT to the two models.

DISCUSSION

This study examined only seven independent variables towards asthenopia. The psychological factors were not measured. This is the limitation of study. It was suggested to include these factors in future asthenopia research.

Seven variables were analyzed towards macular recovery time as the objective measurement of asthenopia[2]. Asthenopia was measured objectively with a modified photostress test to the computer workers. The objective measurement of asthenopia was very important since asthenopia was defined as a group of subjective complaints among computer workers, which was difficult to measure[2,1].

The prevalence of asthenopia based on anamneses or the subjective results among operators, the highest reported percentage : 69.3% were eye and vision discomfort while among the administrative workers, the highest percentage was neck pain (47.67%). The prevalence of MRT among operators was 21 subjects (50.0%) and among administrative workers 11 subjects (26.2%). The disparities between those figures showed the benefits of using the objective measure.

The workers could not lie of being sick. This benefit could be used by the company to decrease the absentees of workers and at the same time if the workers have asthenopia, they should be well treated.

For chronic cases in which the workers have been suffering for quite a long time, they should be transferred to another department with different type of work that does not use computers.

The objective parameter also helps research workers to identify risk factors in the asthenopia model through logistic regression function[18]. Significant risk factors, confounders and effect modifier could then be determined. The significant risk factors are the factors which influence the occurence of an outcome of interest. The confounders were risk factors which influence indirectly through risk factors the occorence of an outcome while effect modifiers effect risk factor towards the occurence of an outcome through the interaction variable. Confounding bias occured when the effects of two risk factors are mixed in the occurence of an outcome while effect modification concerned how the presence of an additional risk factor changed the magnitude of the association between a given exposure and a health outcome. Both confounder and effect modifier if existed, the effects should be corrected[17].

The analysis of risk factors for the whole groups, using the association test reported several major risk factors of asthenopia, i.e, type of exposure, OR 3.82 (CI 1.14-6.96), women workers OR 6.91 (CI 1.81-26.34) and Hb content OR 99.0 (CI 2.66-3686.87); Based on these findings, Hb was the determinant of asthenopia.

The comprehensive model analysis through log-reg function reported in model 1, that type of exposure for the whole samples was a the major risk factor while duration of work and illumination were confounders for type of exposure to MRT. Hb content was not proven as a risk factor neither a confounder as well as an effect modifier for the whole samples. Hb content was proven at the log-reg analysis of model 2, stratified by type of exposure, the highly exposed or the operators neither model as a confounder for sex to MRT. Hb content was neither proven as a risk factor nor a confounder as well as an effect modifier among all small models i.e., the administrative workers model, the female and male operators models and the female and male administrator workers models.

These findings showed that Hb content could not be considered as the determinant of asthenopia as being proven by the association test. Hb content will affect indirectly asthennopia through gender meaning if it happened that there were siqnificant increase in the prevalence of asthenopia and also significant different between female and male operator workers, blood Hb content in both male and female operators should be checked and corrected.

Sex was neither proven as a risk factor nor a confounder or an effect modifier in all models. It did not confirm the role of women workers as risk factor to asthenopia as reported some where above.

The log-reg function analysis did not back up the test of association results due to small sample problem[22]. Even the total sample was considered small, the stratified models were smaller. It should be borne in mind that the study was exploratory and the number of samples collected in this study was restricted due to certain reasons, eventhough the sample size was met according to the estimated calculated sample size[16]. For model analysis, bigger sample size is required[18,22]. Thus, for determining asthenopia risk factors among computer workers, it is suggested to conduct a multicenter or a multicompany study to provide large samples.

CONCLUSIONS AND SUGGESTIONS

The role of blood Hb content among computer operator workers in the company is reported as a confounder for gender to asthenopia. It is suggested for the computer company to conduct blood Hb test regularly among male and female operator workers to maintain their work productivity.

For the whole group, Hb was neither proven as the significant risk factor, nor a confounder or an effect modifier. Duration of work and illumination were identified as confounders of type of exposure to asthenopia.

It is also proven that in all groups : the whole group and the stratified groups, no significant risk factor was indentified, which is presumably due to small sample size.

Bigger sample size is required to determine significant risk factors, confounders and effect modifiers of asthenopia through a model building statistical analysis, the logistic regression function technique. It is suggested to conduct a multicompany research among computer workers, to provide large samples to analyze asthenopia risk factors.

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